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An Investigation of the Accuracy of Refixing Broken Teeth to Stone Casts

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Abstract - *This study investigated the error in refixing fractured teeth to stone casts. Teeth vulnerable to fracture and adjacent teeth for controls on the same casts were scanned using the Triclone contact scanner. The vulnerable teeth were fractured and refixed using cyanoacrylate adhesive and the casts rescanned. Altogether 35 teeth were fractured and repaired in this way. The mean distance displacement of the repaired teeth was 0.23 mm in the XY (horizontal) plane and 0.1 mm in the Z axis. The mean angular displacement was 0.72°. We can conclude that the angular displacement of the repaired teeth contributed significantly to the measured distance displacement.*

KEY WORDS: Dental cast. cyanoacrylate adhesive. partial denture

INTRODUCTION

In dental clinics and laboratories alike, teeth may be accidentally fractured from stone casts intended for the construction of prostheses. Whether it is in removing the impression from the cast, or later, having failed to block undercuts appropriately or simply dropping the cast on the ground, the effect is the same: usually single teeth, often elongated and weakened by gingival recession, which have become fractured from the cast.

Plaster and stone make a brittle fracture so the broken surfaces may be often convincingly apposed and permanently fixed with a suitable adhesive. However, the experience of many is that proceeding with a repaired cast is unwise and may lead to disappointment when the prosthesis is constructed but fails to fit the mouth.

A study by Sanad, Combe and Grant[1] investigated the repair of fractured dental stone cylinders 6mm in diameter using four different adhesives. Zinc phosphate and zinc carboxylate cements had thickness and prevented contact of the fractured surfaces but cyanoacrylate and polyacrylic acid as adhesives had apparently no film thickness.

Cyanoacrylate in many dental laboratories remains the standard repair kit for broken casts. Besides this one study and the accepted wisdom that repaired casts are not reliable we have found no other study which has attempted to measure the error in repairing broken teeth on stone casts. This was therefore the purpose of this investigation.

MATERIALS AND METHODS

For a preliminary investigation two casts were made each with four regular cylinders on a plane surface. On one cast the cylinders were 5 mm diameter and the other 7mm diameter and the height 12mm. Using a laboratory duplicating medium the casts were duplicated and poured with Kaffir D dental stone (30ml water to 100gms stone) to make two copies of each of the original casts (figure 1). The casts were measured using the Triclone 90 contact scanner using the cylinder measuring function which recorded XYZ coordinates of the centre of each cylinder. However due to irregularities in the stone cylinders which the scanner could not recognise, a short cylinder of aluminium 10mm in diameter was cemented with cyanoacrylate to the "occlusal" surface of each (figure2). The casts were located in the scanner with the magnetic plate provided which was cemented to the base of each cast.

Having scanned the unbroken casts three of the cylinders from each cast were fractured by hand leaving the fourth cylinder unbroken as a control. The fractured cylinders were refixed using cyanoacrylate adhesive and the casts scanned again including the unbroken control cylinder.

In the main study, five casts were selected from cases in the laboratory having a potential of seven isolated teeth to be fractured (three canines, three premolars and one lower incisor). Wax was applied to the occlusal surfaces of the vulnerable teeth and at least one adjacent tooth on each cast for control (figure 3). The wax was flattened to the tip of the cusp to provide a surface to which the aluminium cylinders could be cemented after the casts had been duplicated (figure 4). Five duplicate casts were made of each in Kaffir D dental stone and after scanning in the Triclone 90 the selected teeth were fractured and repaired using cyanoacrylate adhesive and scanned again as before. All the fractures and repairs were made by the same author of this paper (PL).

The casts were positioned in the scanner with the occlusal plane horizontal which corresponded with the XY axes. Any change in height of the teeth as a result of the fracture and repair was recorded in the Z axis. The scanner recorded the XYZ coordinates for the centre of each of the aluminium cylinders cemented onto the fractured teeth and controls; in addition it recorded vectors of the flat surface of the top of the cylinder to establish any angular change as a result of the repair.

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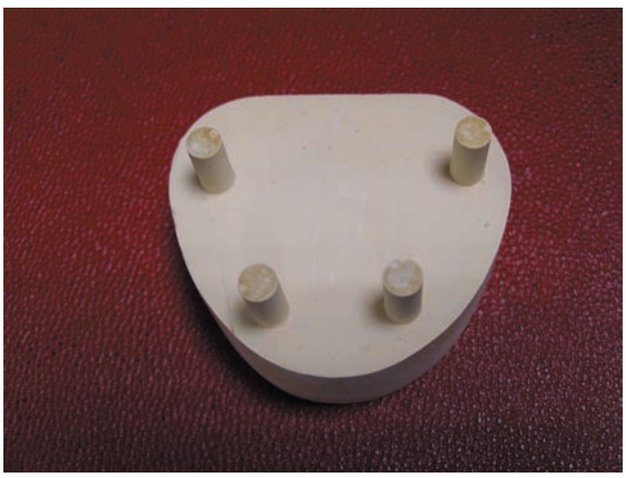

Figure 1. *Preliminary study cast comprising four stone cylinders on a plane surface.*

Figure 3. *Cast from the main study. Wax has been added to the occlusal surfaces of the premolar and canine (control) before duplicating the master cast.*

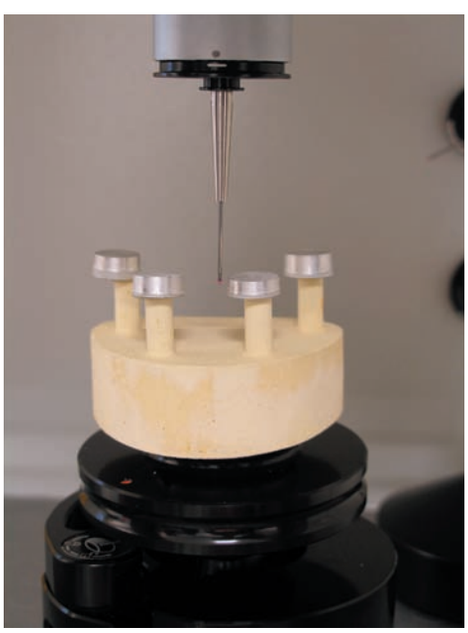

Figure 2. *Cast from figure 1 in the Triclone 90 scanner. An aluminium cylinder has been fixed to the top of each of the four cylinders for the scanner to recognize.*

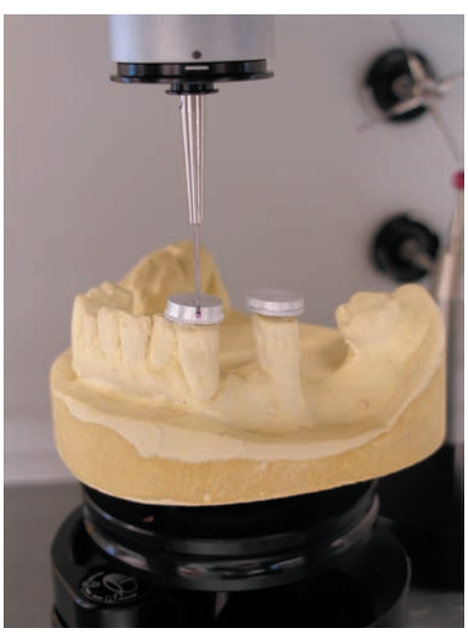

Figure 4. *Cast from figure 3, with aluminium cylinders attached, in the Triclone 90 scanner. Later the premolar will be fractured and refixed and the cast scanned again.*

A printout from the computer showed the XYZ coordinates for each of the selected teeth before and after the fracture and repair, as well as that of the controls, in addition to any change in angulation of the aluminium cylinders. Assessment of the displacement of the repaired teeth was made with reference to the displacement of the controls which was sometimes in the same and sometimes in the opposite direction to the repaired teeth and the appropriate correction made. Simple trigonometric calculation gave the distance the repaired teeth were removed from their original position in the horizontal plane as a single figure (mm) without reference to the direction of displacement.

RESULTS

The results are presented for the displacement of the fractured teeth in the XY and Z axes as well as the calculated displacement in the XY plane from their original position. The change in angulation of the aluminium cylinders is also shown. Results shown in Table 1 are the results of the preliminary investigation. The displacements recorded in the preliminary study were greater than found in the main study and this may be because it proved easier to reposition a fractured tooth on the cast than a regular cylinder on an otherwise plane surface.

The results for the main study are shown in Table 2 for the same coordinates as in Table 1. The XY Displacement is expressed without reference to the direction of displacement but analysis of the results showed no singular direction of displacement for the repaired teeth either on any of the individual casts or in the results for the whole study.

The mean XY displacement of 35 teeth on 25 casts which were fractured and repaired in this study, after correction for the displacement of the control unfractured tooth was 0.23 mm, (standard deviation 0.27 mm) and 0.1 mm, (standard deviation 0.07 mm) in the Z axis. Mean displacement of the controls, which comprised any repositioning error of the cast or error in the scanning machine, was 0.015 mm in the XY plane and 0.006 mm in the Z axis, or less than 10% of the measured displacement of the repaired teeth. The mean angular displacement of the repaired teeth was 0.72 degrees, (standard deviation 0.94 °.). On account of some outlying results the median for each result is also shown in Table 2,0.16 mm for the XY displacement, 0.07 for the Z displacement and 0.48 ° degrees for the angular displacement.

The correlation of the XY displacement of the repaired teeth with the angular displacement of the aluminium cylinder on each tooth showed a Pearson Correlation Coefficient of 0.83 P<0.001 which confirms the angular displacement as an important part of the error in the repair of the fractured teeth. There was a weaker correlation between the angular displacement and the Z displacement: = 0.71 P<0.001

Dentists attending the annual conference of the British Society for the Study of Prosthetic Dentistry in 2005 were invited to participate in a small sub study. They were invited to fracture one tooth from a provided cast, to repair it with the cyanoacrylate and offer the cast for scanning (N=18). The displacements measured in this part of the investigation are shown in Table 3 and are rather less than the results for displacement of the fractured teeth in the main study.

DISCUSSION

Anecdotal sources have suggested a tolerance of 0.1mm for fitting a cobalt chromium framework for partial dentures although in practice the matter is one of clinical judgement. Stern et al [2] judged a good fit of occlusal rests as closer than 0.05 mm but Fenlon et al [3] showed comprehensively how different parts of the same framework may not fit the master cast by several times this amount due to under compensation by the investment for casting shrinkage. Likeman and Juszczyk [4] showed this could amount to 1% or 0.1 mm for every centimetre dimension of the entire framework.

Sources of error in repairing a fractured tooth might include a step error in refixing the tooth or as this study has shown an angular displacement from the original position. Some of the outlying results might have been due to loss of fragments of stone from between the fractured surfaces when the fracture occurred.

Table 1. *Results for the preliminary investigation*

	X	*Y*	*XY displacement*	*Z*	*Angular disp*
Model 1 (5mm cylinders)	0.23mm (sd 0.18)	0.21mm (sd 0.12)	0.31 mm (sd 0.17)	0.09mm (sd 0.06)	0.49 ° (sd 0.26)
Model 2 (7mm cylinders)	0.14mm (sd 0.1)	0.36mm (sd 0.36)	0.39 mm (sd 0.30)	0.12mm (sd 0.05)	1.2 ° (sd 0.74)

XY displacement = $\sqrt{X^2+Y^2}$
Correlation of XY displacement with angular displacement: 0.844 P= 0.035

Table 2. *Results of the main study*

	X mm.	*Y mm*	*XY displacement mm.*	*Z mm*	*Angular disp degrees*
Mean	0.1	0.19	0.23	0.1	0.72 °
Standard deviation	0.13	0.26	0.27	0.07	0.94
Median	0.06	0.12	0.16	0.07	0.48 °

Correlation of XY displacement with angular displacement: 0.828 P< 0.001
Correlation of Z displacement with angular displacement: 0.713 P< 0.001
Correlation of XY displacement with Z displacement: 0.453 P= 0.006

Table 3. *Results for displacement of 18 teeth fractured and repaired by Dentists attending the BSSPD Conference*

	X mm	*Y mm*	*XY displacement mm*	*Z mm*	*Angular disp degrees*
Mean	0.09	0.13	0.17	0.07	0.5 °
Standard deviation	0.08	0.13	0.13	0.05	0.35
Median	0.07	0.09	0.14	0.05	0.5 °

Correlation of XY displacement with angular displacement: 0.654 P= 0.003
Correlation of Z displacement with angular displacement: 0.333 not significant
Correlation of XY displacement with Z displacement: 0.248 not significant

Z axis displacement related to the thickness of the adhesive but necessarily the point of rotation of any angular displacement would be at the edge of the tooth and produce a change in height at the point of measurement which was the centre.

It is a basic requirement that the cast should be an accurate representation of the mouth and the denture should fit he mouth the way it fits the cast. The problem of a single tooth fractured and inaccurately replaced is not only that the framework does not fit that tooth but it may prevent the whole of the remainder of the framework from fitting. The situation in the mouth of a framework fitting all but one tooth suggests some damage to the cast before the refractory cast was made.

All of the teeth fractured in this study were elongated and some had already been fractured and repaired before they were duplicated for use in the present study. It is acknowledged that the addition of the height of the wax and aluminium cylinder (3 - 5 mm) to the occlusal surfaces exaggerated the displacement caused by the angular discrepancy. The average height of all the fractured teeth and the attached cylinders was 13.2 mm, possibly double the height at which level a framework would have fitted the concerned tooth and therefore potentially increases the displacement. However, the intention of this investigation was not to understate the problem and the greater discrepancies we have shown would still have been be important even if reduced by half.

The risk of constructing a framework on a cast which has been fractured and repaired must be measured against the chance of having to make a new impression and construct the framework again, with the consequent frustration of dentist and patient alike. The reputation of the dental technician is also brought under scrutiny.

CONCLUSION

This study has quantified the error which may occur from the refixing of fractured teeth to stone casts; in particular it has shown a significant relationship between the angular and horizontal displacements (XY) of repaired teeth from their original positions.

Any such repaired cast should be regarded with the utmost suspicion and probably discarded.

MANUFACTURERS

- Kaffir D dental stone. British Gypsum, Newark, Notts
- Cyanoacrylate adhesive. Laborfix, Bracon Ltd. Etchingham, East Sussex.
- Triclone 90 scanner. Renishaw Ltd, Wotton-under Edge, Glos.

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